

A COMMUNITY-LEVEL FLORISTIC RECONNAISSANCE OF THE RAJA AMPAT ISLANDS IN NEW GUINEA

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ABSTRACT

The Raja Ampat district of Indonesian Papua is one of New Guinea's most unusual floristic environments. A recent rapid-assessment survey examined vegetation patterns across the district, characterizing the major plant communities and identifying existing biodiversity threats. Mangroves, beach forest, lowland hill forest, limestone karst, and ultrabasic (serpentine) woodland were the principal natural-growth habitats explored by the botanical team. Although several lowland areas are being degraded by concessional logging, most of the limestone communities remain in pristine condition. There are substantial prospects for future taxonomic discovery.

KEY WORDS: botanical survey, limestone karst, Papua, serpentine, ultrabasics

ABSTRACT

インドネシア領パプアのラヤアンパット地域はニューギニアの最も特徴ある植生地域の一つである。最近のラピッドアセスメント調査において、地域の植生パターン、植物群落の特徴、存在する生物多様性破壊の危機について調べられた。マングローブ林、海岸林、低地丘陵林、石灰岩カルスト、超塩基性土壌（蛇紋岩）林が今回調査を行った主な自然植生帯である。幾つかの低地林は商業伐採による植生の攪乱が見られたが、殆どの石灰岩土壌地域は原植生の状態を保っており、分類学上の価値ある発見がされる可能性が高いと思われる。

キーワード：植生調査、石灰岩カルスト、パプア、蛇紋岩、超塩基性土壌

INTRODUCTION

Located at the far western end of New Guinea, the Raja Ampat islands (Figs. 1, 2) are one of Malesia's little-known environmental jewels. In addition to spectacular coastal vistas deserving of World Heritage recognition, recent studies have determined that the islands probably have the highest levels of coral and reef fish diversity in the world (Reefbase 2002). Floristically, the Raja Ampat contain 3 of the 22 Papuan areas recognized as centers of very high endemism (Supriatna 1999).

Most of western New Guinea (including Misool and northern Salawati) are

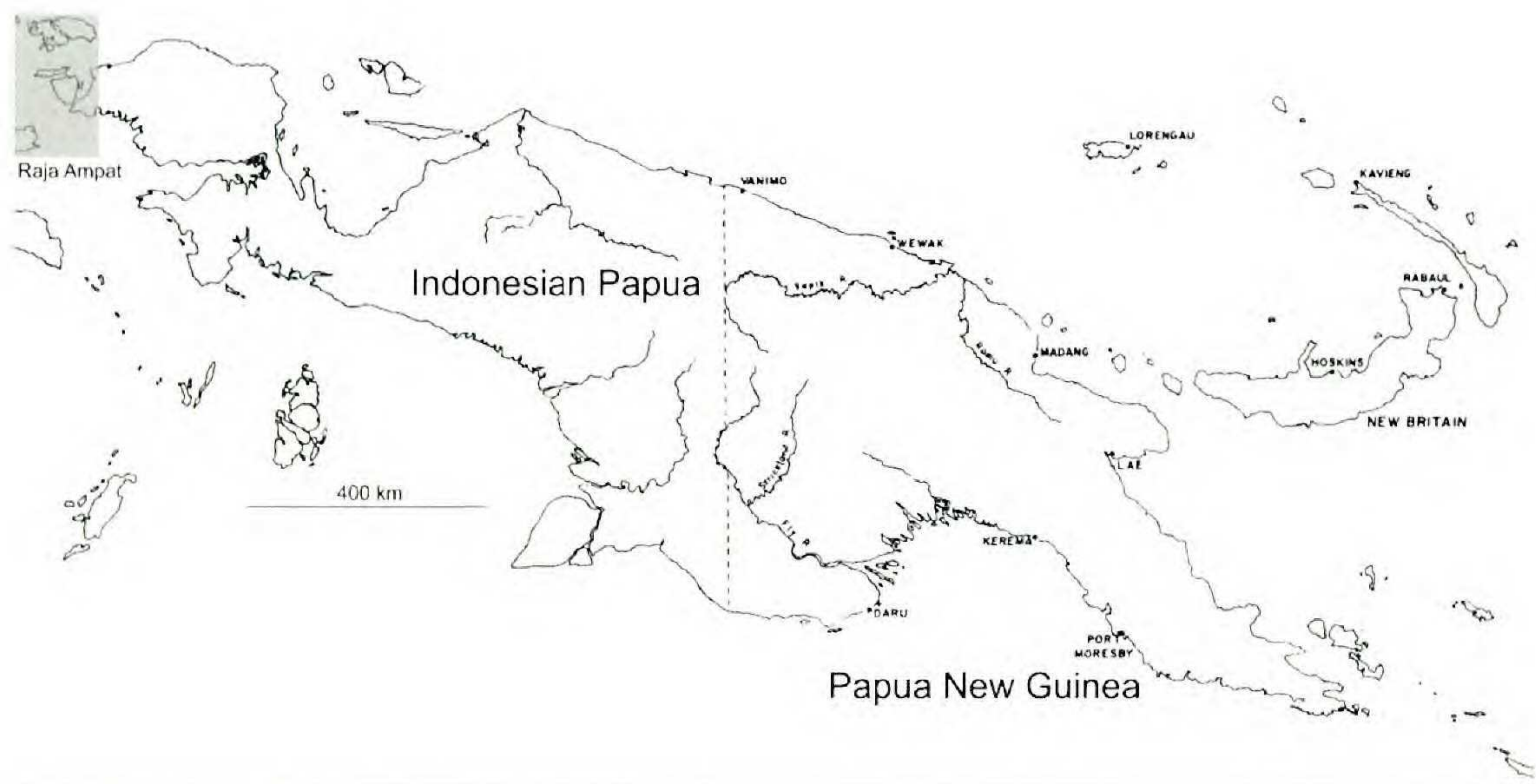


FIG. 1. Island of New Guinea. Shaded area: Raja Ampat district.

part of a Papuan microcontinent which separated from the Gondwanic land-mass during the early Mesozoic, subsequently drifting into its present position independently of the Australian craton (Pigram & Panggabean 1984; Pigram & Davies 1987; Hall 1998). Waigeo and adjacent islands comprise one of only two oceanic terranes in this region of New Guinea. Especially in the westernmost islands, ultrabasic and limestone substrates have developed distinctive plant communities containing many endemic species.

Ironically, considering the overall paucity of information for such environments, the Raja Ampat was among the first areas to be visited by early explorer-naturalists to eastern Malesia. In 1792–93, the vessels *Recherche* and *Esperance* obtained plant collections from Waigeo as part of a general program of regional exploration. Botanical specimens were also taken during visits by the *Uranie* and *Physicienne* in 1818–19, and during the cruise of the *Astrolabe* (1826–29). Early collectors included Beccari (1872–73) on Batanta and Kofiau, and Micholitz in 1890, also on Batanta. Frodin and Gressitt (1982) provide a general account of these early activities. Following the efforts of Cheesman on Waigeo (1938–39) and by Royen on Batanta and Waigeo (Royen 1960), there was little serious work in the district. Most of the interior sections remain unknown because of the physical difficulties of access and the nearly total absence of service infrastructures.

MATERIALS AND METHODS

The Nature Conservancy (TNC) survey of the Raja Ampat was designed primarily to investigate the diverse reef ecosystems of the area, and secondarily to identify linked land-marine conservation targets for possible community-based initiatives. During a 3-week period (Oct. 30 to Nov. 22, 2002) the scientific team

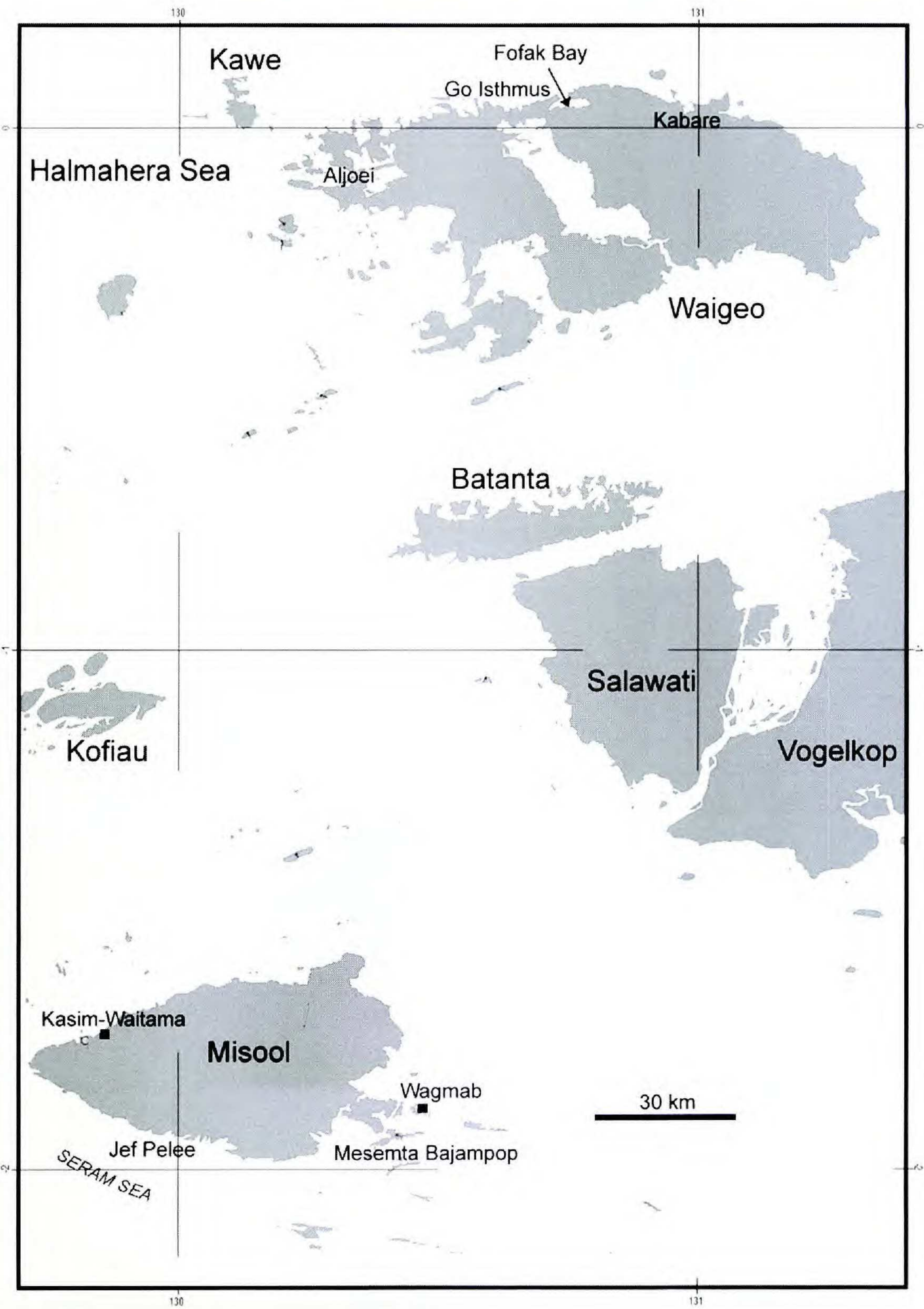


FIG. 2. Raja Ampat District. Principal localities from the TNC biological reconnaissance. Sayang and Wayag islands are (respectively) 35 and 17 km NW of Kawe and outside the map boundaries.

made numerous stopovers among all the main islands, using a chartered diving vessel (the *Pindito*) as a live-aboard mobile base. As ecologist for the forest assessment, the writer was responsible for describing the principal vegetation types and ground-truthing perceived community distributions against a preliminary classification developed from the RePPPProT (Regional Physical Planning Program for Transmigration) plant typology maps (RePPPProT 1990; Hardiono 2002). The floristic evaluations and botanical collecting were conducted with assistance by Duncan Neville (TNC Sulawesi Manager), Johanis Mogeia (Herbarium Bogoriense), and Fery Liuw (Departemen Kehutanan Papua).

Forest communities were examined in *ad hoc* fashion, via walk-through assessment of areas accessed by dinghy or speedboat (Figs. 3–5). Community variation was documented by numerous photographs referenced with readings from a handheld GPS recorder. These onshore activities were necessarily constrained by the collateral marine studies and the corresponding movements of the *Pindito*. Because of the constantly shifting itineraries of the marine team, the forest participants could usually devote only one day to a given site, thus restricting survey coverage to areas near the coast.

Botanical collections were typically made in sets of 5 duplicates whenever fertile specimens were found. Gatherings were field-packed in newsprint and plastic bags, then soaked with 70% ethanol for subsequent processing at Herbarium Bogoriense (BO). Silica-dried samples for DNA sequencing were also obtained if specialists had placed earlier requests for assistance. In order to simplify the vouchersing process, collections were numbered under the sequence of botanist J. Mogeia. Specimen distributions will occur from BO, with A, K, L, and MAN as the principal recipients (Irawati pers. comm.). A taxonomic account of the botanical findings is being prepared by Mogeia for separate publication.

RESULTS

Botanical observation and collecting were complicated by drought conditions caused by the recent El Niño disturbance. The collections tally (550 nos.: Mogeia et al. 7726–8276) includes about 100 sterile numbers because of the unfavorable phenology. Although the entire district showed signs of drought stress, the severity of the disturbance was greatest in the outer islands (Misool, Kawe, and Waigeo; Fig. 6). At Batanta and Salawati, forest canopies were mostly green (although understories were very dry) and there were even brief periods of torrential rain during the visit to those islands.

Among the habitats covered by the TNC-modified RePPPProT forest classification, mangroves were apparently the only natural-growth community which could be accurately mapped using Landsat reflectance patterns (see Hardiono 2002). Topographic and geological maps proved of greater value than any existing forest typing system. The lack of a GIS-based classification equivalent to the Papua New Guinea Resource Information System (PNGRIS) and its

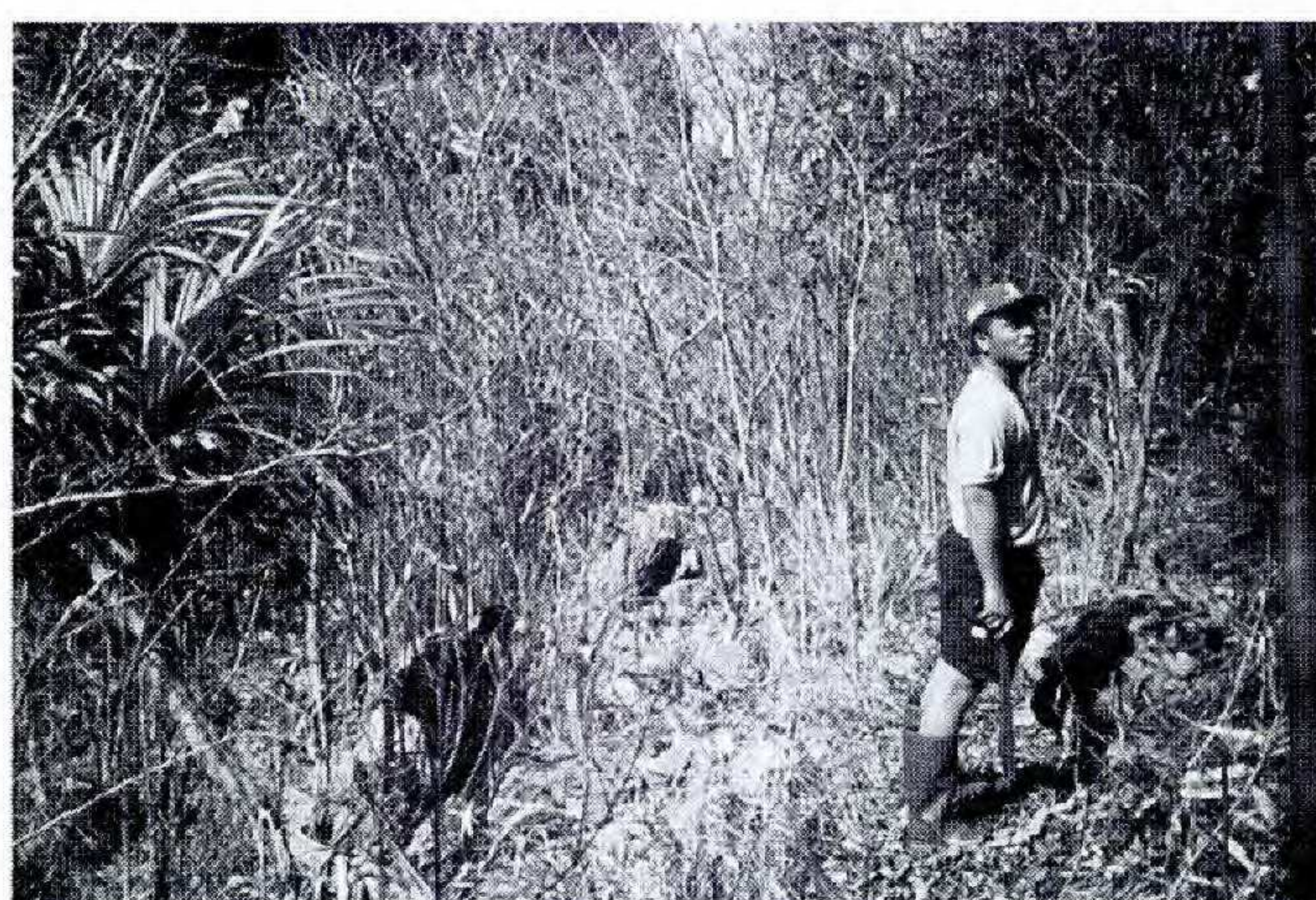


FIG. 3. Land team members (Duncan Neville and Fery Liuw) boarding a zodiac after surveying an island in the Jef Pelee group. The 75-ft Pindito lies anchored offshore. Zodiac and speedboat tenders provided daily transport for the land-sea survey. Photo November 9, 2002.

FIG. 4. For travel over longer distances, the team used a speedboat ('longboat') of a versatile design widely employed in the Papuan coastal and riverine traffic. Despite their unwieldy appearance the shallow-draft longboats are capable of entering the headwaters of even small streams. A survey longboat is shown here at Wagmab Island. Photo November 4, 2002.

FIG. 5. Wagmab Island, SE Misool. Forester Fery Liuw searches for botanical specimens in the dry scrub on limestone talus. In spite of exemplary support logistics, collections were few and difficult to obtain because of the unfavorable conditions. Photo November 4, 2002.



FIG. 6. Kawe. Drought-stricken serpentine woodland on steep slopes. Photo November 18, 2002.

generically related Forest Inventory Mapping System (FIMS), is a serious obstacle to survey planning in western New Guinea (see Bellamy & McAlpine 1995; Hammermaster & Saunders 1995a, b). To facilitate comparisons with the FIMS classification, the following community descriptions are prefaced by the structural code (in parentheses) for the corresponding formations in East New Guinea.

The expedition included 15 fulltime participants, of which 5 were journalists or photographers. As a result of the intensive media coverage, survey images and preliminary findings are available on several websites (<http://www.reefbase.org/RajaAmpat/>; <http://www.AliensOfTheSea.com/HDTV>; <http://www.projectbirdwatch.org/rajaampatrea/>).

Principal Communities

Mangroves.—(M) Of all the vegetation types encountered on the survey, the mangrove communities are probably the best-studied (e.g. Backer & Steenis 1951; Ding Hou 1957, 1958, 1960; Percival & Womersley 1975; Floyd 1977; Duke & Jackes 1987; Erftemeijer et al. 1989; Duke 1991; Mabberley et al. 1995). Unlike the situation in nearby Telek Bintuni (cf. Erftemeijer et al. 1989; Takeuchi et al. in press), Raja Ampat mangroves are insignificant and markedly impoverished, except in a few places where estuarine flats and tidal rivers have provided ample habitat for the *Bruguiera-Rhizophora* associations (Fig. 7). Among investigated



FIG. 7. Wayag Island. Interior view of a mangrove forest on limestone karst. Trees are represented mostly by *Bruguiera gymnorhiza* and *Rhizophora mucronata*. Photo November 16, 2002.

sites, the best examples of this community were seen on Pulau Misool, along the lower Gam and Kasim rivers. At the second locality, there is a well-developed upstream sequence (in order) of *Rhizophora mucronata* – *Ceriops tagal*, *Bruguiera gymnorhiza*, *Nypa fruticans*, then a final freshwater assemblage consisting of *Xylocarpus granatum*, *Dolichandrone spathacea*, and *Heritiera littoralis*. However in most parts of the archipelago, mangroves are represented (if at all) only by isolated trees along a foreshore, with no horizontal development of the community.

Swamp woodland.—(Wsw) Monodominant forests of *Metroxylon sagu* (sago) are scattered through the Raja Ampat district, wherever soil flooding is severe. The occurrences are insensitive to substrate. Sago swamps are found on limestone at Kofiau (01°09'25S, 129°51'38E), and on mineral clays at Kapatlap, Salawati. Although the floristic diversity is very low, sago communities are of considerable subsistence value as a source of dietary starch obtained from the *Metroxylon* trunks (cf. Powell 1976; Johns & Hay 1984).

Littoral or beach forest.—(B) A distinctive community along many coastlines, beach forests are mostly composed of widely distributed, even pantropical taxa, but have been reduced over much of their former range because of anthropogenic pressures (Wikramanayake et al. 2001). The principal indicator species for this community are *Calophyllum inophyllum*, *Hibiscus tiliaceus*,



FIG. 8. Open beach forest on Wagmab. In the western Raja Ampat, mangroves and beach forest are generally scarce. The limestone and serpentine vegetation often extend to the highwater line, displacing the beachfront communities more characteristic of other coastal areas. Photo November 4, 2002.

Pandanus tectorius sens. lat., *Terminalia catappa*, and *Thespesia populnea* (Fig. 8). In the Raja Ampat other associates often included *Colubrina asiatica*, *Parsonia alboflavescens*, *Derris indica* (*Pongamia pinnata*), *Tacca leontopetaloides*, *Ximenia americana* var. *americana*, and *Vigna marina*. Beach forest generally occurs on sand or coralline rubble behind the strand zone. A particularly good example was seen at N Kofiau (01°09'24S, 129°50'47E). On uninhabited Sayang Island (0°16'24S, 129°53'47E), a different type of beach association (BCe) was recorded on sandy flats, consisting of *Casuarina equisetifolia*, *Scaevola sericea*, *Sophora tomentosa* ssp. *tomentosa*, *Spinifex littoreus*, and *Tournefortia argentea*.

Lowland forest on deep mineralized soil.—(Pl, Hm) The land team encountered this community type near Kapatlap on Salawati, and on the north and south shores of Batanta, where the vegetation is predominantly a tall stature rainforest similar to those from coastal lowlands of the Bomberai Peninsula. Deep soil habitats (in the eastern Raja Ampat) were probably the most speciose of all the surveyed environments, but were also characterized by plants common in adjacent mainland areas and thus of comparatively low conservation interest (Figs. 9, 10). *Intsia bijuga*, *Koordersiodendron pinnatum*, *Pometia pinnata*, and *Terminalia* cf. *copelandii* were dominant trees in such situations, with *Celtis*, *Ficus*, *Dysoxylum*, *Myristica*, and *Syzygium* the best-represented genera in the subcanopy. The regrowth phase included *Alstonia scholaris*, *Gastonia serratifolia*, *Morinda citrifolia*, and *Trema cannabina* as the most prominent species, at least within the logged-over tracts seen on Batanta and Misool.

In the western Raja Ampat, deep soil habitats are generally absent except in the flood plain of large rivers (e.g. Gam and Kasim rivers), or in the ravines on limestone karst (e.g. the numerous islets near Mesemta Bajampop of SE Misool). Such areas have tall forests comparable to the Batanta/Salawati formations, but are species-poor and usually less than 1 ha in size (Figs. 11–13). Frequently, the stands are composed of *Intsia bijuga*, *I. palembanica*, *Vatica rassak*, or *Pometia pinnata*; with *Jagera javanica* ssp. *javanica*, *Trophis philippinensis*, *Teijsmanniodendron bogoriense* (uncommon), and *Maniltoa* spp. (*M. plurijuga* and *M. schefferi*) underneath. *Flindersia amboinensis* and *F. laevigata* var. *heterophylla* are conspicuous emergents in these tall-forest pockets on the smaller islands, particularly in the Misool group. *Osmoxylon sessiliflorum* was especially prominent in subcanopies near rivers (Misool). At Jef Pelee (S. Misool) a *Homalium foetidum* monodominant forest was encountered on ridge slopes and crests (Figs. 14, 15; 02°01'09S, 130°01'28E).

The forest understories in the Raja Ampat are harder to characterize. Generally when the canopy has at least 25–50% closure the groundlayer is already clear. Representative communities in the Misool group had either an open understory, or a palm-dominant layer of *Licuala* and rosette-stage *Calamus* (Figs.



FIG. 9. Forest understory on south Batanta, generally species-rich in comparison to the outer Raja Ampat. Photo November 3, 2002.

FIG. 10. Batanta. Lowland coastal forest on deep soils, in the process of conversion to subsistence gardens. Tall canopies (>30 m height) are common on islands close to the New Guinea mainland (i.e. Batanta and Salawati) but are essentially absent on the outer islands. Photo November 3, 2002.

FIG. 11. Wagemab. Forest in broad ravine. Communities are denser, taller, and richer than the surrounding vegetation on higher slopes. Photo November 4, 2002.

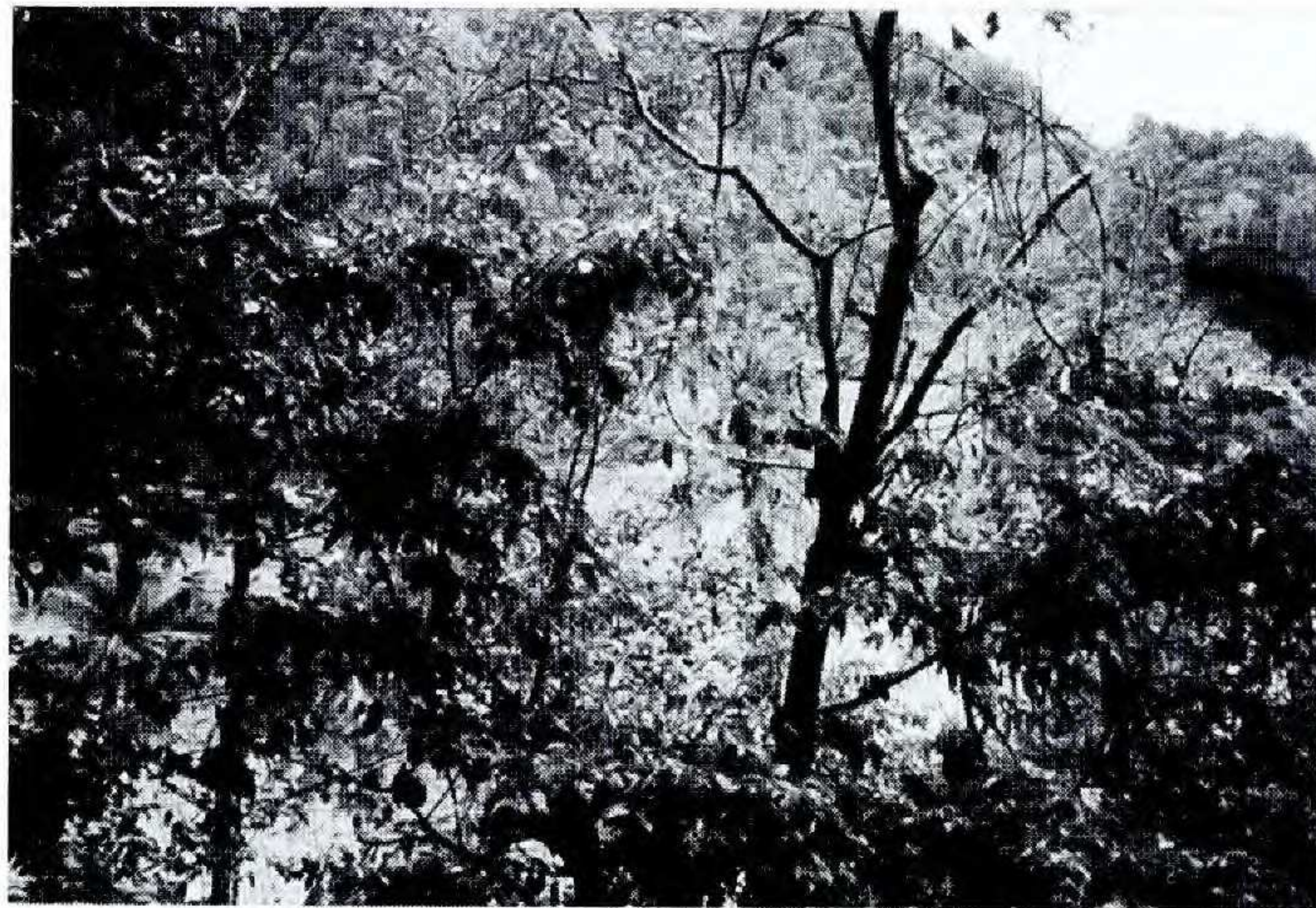


FIG. 12. Interior view of the forest shown in Fig. 11. Photo November 4, 2002.

FIG. 13. Alluvial forest along the Kasim River of western Misool. Photo November 10, 2002.

FIG. 14. Misool. Interior perspective of a *Homalium foetidum*-dominant forest on ridgecrests. Photo November 9, 2002.

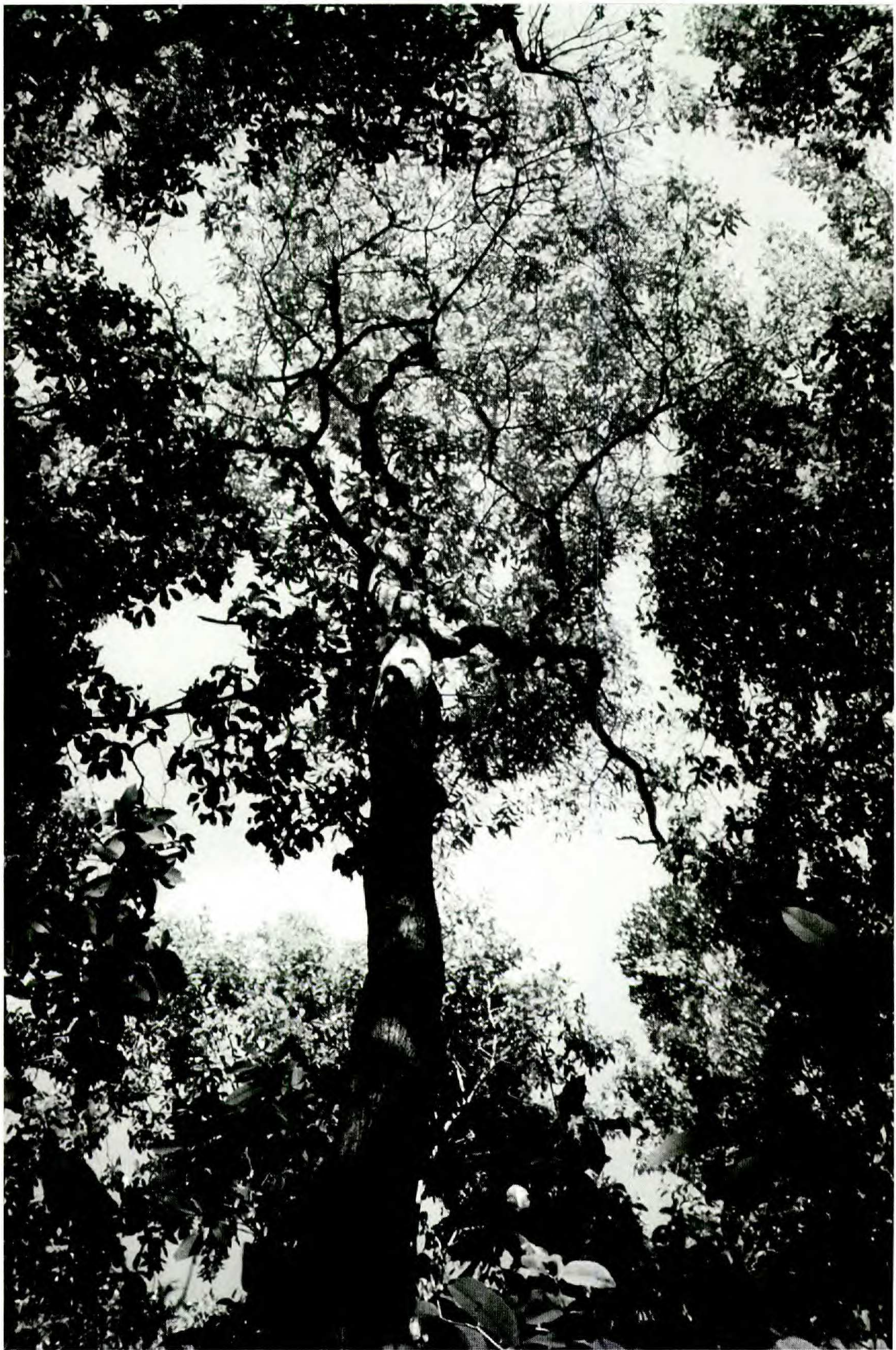


FIG. 15. As for preceding figure. Showing the canopy closure and crown density. Photo November 9, 2002.



FIG. 16. Misool. Understory of a limestone forest. The near-ground interval is generally clear or with scattered palms. Photo November 4, 2002.

16, 17). Ferns, herbs, and cryptogams were hardly ever seen, but it is not known to what extent their absence was due to the severe drought conditions then prevailing. Understories with diverse fern populations (*Bolbitis*, *Davallia*, *Drynaria*, *Nephrolepis*, *Sphaerostephanos*, *Tectaria*) were found only in riverine forest near Fanfanlap (W Misool) and at Kofiau (e.g. 01°10'01S, 129°50'30E).

Secondary forests.—(W) A substantial but unknown percentage of the Raja Ampat lowlands has been logged by industrial operators and is presently in various stages of recovery. The secondary forests examined by survey were previously cut at periods ranging from 15 to 30 years ago and are very distinct from more mature communities in the same habitat.

At Kofiau (01°11'03S, 129°43'21E) a 15-year regrowth (Figs. 18, 19) was a depauperate woodland of *Vitex cofassus*, *Morinda citrifolia*, *Conandrium polyanthum*, and *Ficus* spp. (mainly *F. microcarpa* and *F. prasinocarpa*). *Lunasia amara* var. *amara*, *Leea indica*, and various *Antidesma* and *Macaranga* spp. formed a sparse underlayer. In contrast, an adjacent section of unlogged forest was a closed canopy *Pometia*-dominant community with high frequencies of *Diospyros*, *Horsfieldia*, and *Knema*.

On Sayang (a flat sandy island completely logged in 1984; 0°16'38N, 129°53'48E), the regrowth was of similarly depleted composition, consisting for the most part of a remnant *Artocarpus*-*Intsia*-*Pometia* canopy with a second

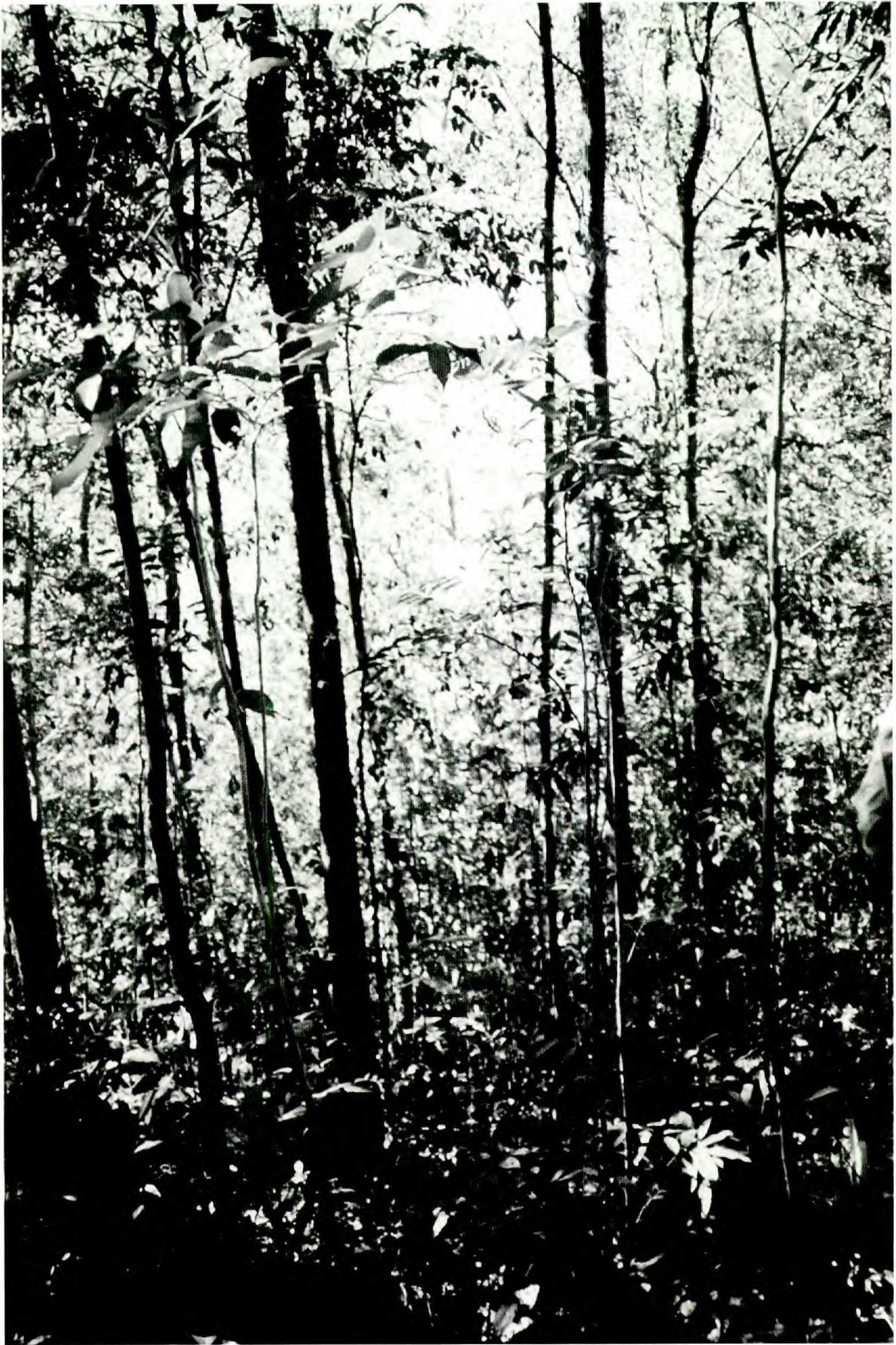


FIG. 17. Kawe. Characteristic appearance of an understory from serpentine stands in ravines and valleys. Stems are generally of small diameter and herbaceous growth is sparse. The ground layer often has seedling crops of the canopy taxa. Ferns and gingers are conspicuously absent. Photo November 18, 2002.



FIGS. 18 and 19. Kofiau. Regrowth community from a former forest clearfelled 15 years ago. Photo November 12, 2002.

story of *Calophyllum inophyllum* and *Aglaia argentea* (the last species previously unrecorded for the Raja Ampat, cf. Pannell 1992). *Conandrium polyanthum*, *Codiaeum variegatum* var. *moluccanum*, and *Polyscias cumingiana* were undergrowth species. Dense seedling crops of *Pometia pinnata* often carpeted the ground in spite of drought conditions.

On a number of small islands, repeated anthropogenic disturbances have erased the former forest and a grassy fire disclimax (G) is now all that exists. At Jef Pelee (coral platform: 02°07'03S, 130°19'00E) most of the land surface is covered by a seral community of *Imperata conferta* with *Ischaemum muticum* on the seaward fringe (Fig. 20).

At Mesemta Bajampop a single example was seen of an early succession on karst, consisting of *Dracaena angustifolia* and *Commersonia bartramia*, with an extensive underlayer of *Gahnia aspera* (Fig. 21).¹

Savanna.—(SaMl) Grassy savannas were recorded only on W Misool, at the mouth of the Kasim River and further inland near the Waitama tributary (01°47'23S, 129°53'57E and 01°51'41S, 129°55'05E respectively). The Kasim com-

¹These sort of communities are the result of localized disturbance and are too small to be mapped by forest classification systems.

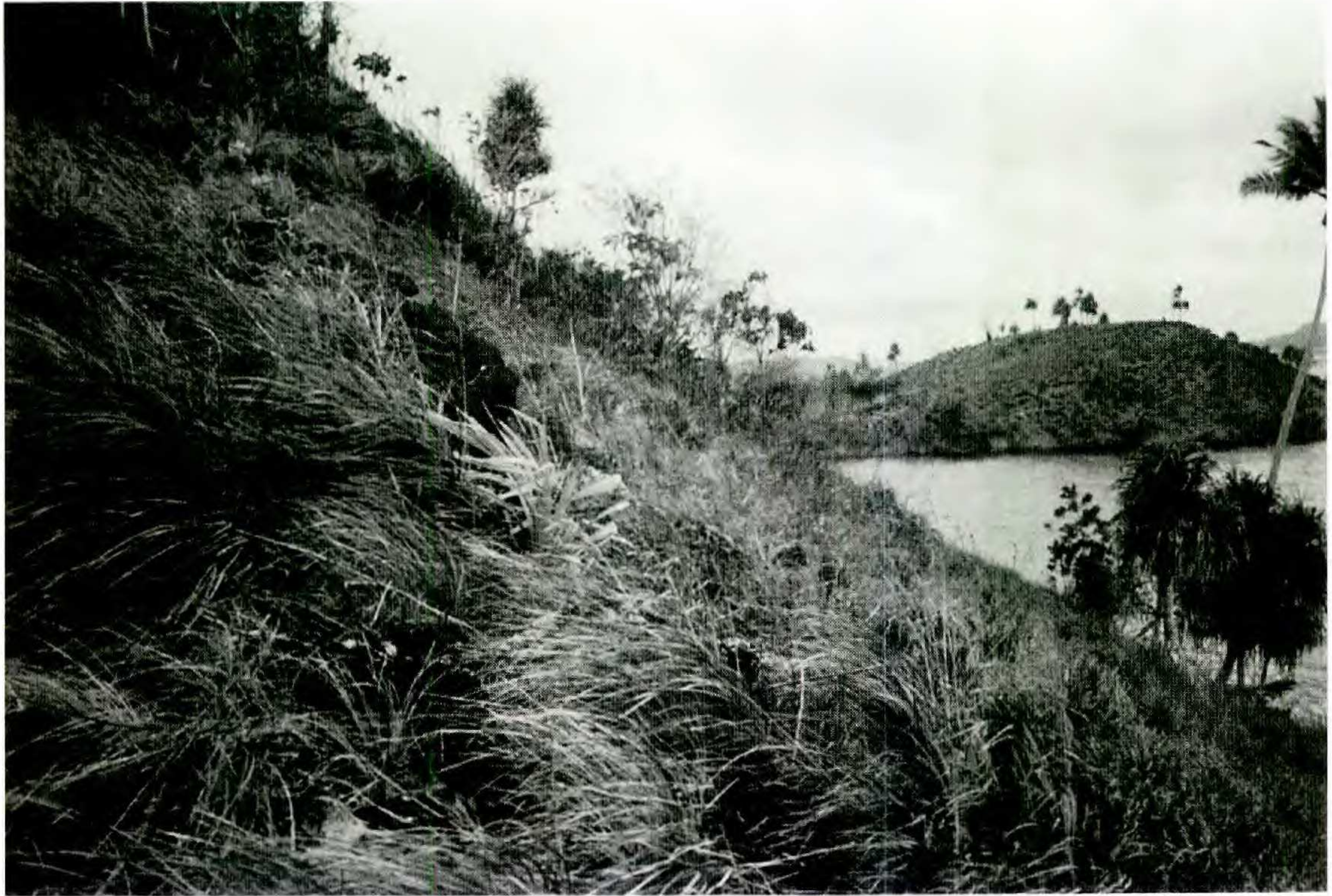


FIG. 20. Jef Pelee. Anthropogenic sedge-grassland (*Imperata-Ischaemum-Scleria*) on limestone islands near the Misool mainland. Other seral taxa included *Desmodium umbellatum*, *Premna serratifolia*, *Morinda citrifolia*, and *Pandanus tectorius*. Photo November 8, 2002.



FIG. 21. Mesemta Bajampop. A seral community on karst, consisting exclusively of *Commersonia bartramia*, *Dracaena angustifolia*, and *Gahnia aspera*. Photo November 5, 2002.

munities were *Melaleuca* dominant, but also included smaller individuals of *Pandanus tectorius* and *Timonius timon* in a distinct second layer (Figs. 22, 23). The dense 2 m+ groundcover was composed of *Ischaemum barbatum* and *Imperata conferta*, together with scattered patches of taller *Saccharum spontaneum* (Fig. 24). Indications of recent burn suggest that the Kasim savanna is probably periodically fired.

The Waitama savannas are larger than the Kasim communities and include *Eucalyptus* cf. *papuana* in addition to the more common *Melaleuca leucadendron* sens. lat. (Fig. 25). Shrubs were commonly represented by *Baeckea frutescens*, *Decaspermum bracteatum*, *Melastoma malabathricum* ssp. *malabathricum*, and a *Polyscias* sp. The groundlayer of *Ischaemum barbatum* and *Rhynchospora rubra* was habitat-partitioned, the latter species mainly occupying flat areas with the poorest drainage.

In appearance and composition the Waitama savannas are nearly identical to comparable formations on the Papuan mainland at Bomberai (cf. Takeuchi et al. in press). The communities at both sites are apparently under substrate control, with characteristic occurrences on flat or gently undulating terrain underlain by hardpan and alumina deposits (pers. obs.). Although the savannas in the Raja Ampat are affected to some degree by fire, the substrate patterns suggest the communities are a longterm response to stable edaphic factors (cf. Paijmans 1976).

Lowland forest on limestone karst.—(Hs, HsCp)² The limestone terrain is one of the most visually stunning and unspoiled environments in the Raja Ampat district. Much of this habitat is a deeply dissected karst which is often extremely difficult and time-consuming to traverse. A small hill can take an entire morning to ascend, so it is not hard to comprehend the relative lack of botanical collections from such areas.

Excellent examples of karst vegetation are found in the Misool chain, particularly in the SW complex of small islets and at the western end of the Misool mainland. Within the Waigeo group, extensive limestone habitats were explored near Aljoei (0°11'43S, 130°15'39E) and at Wayag (0°10'21N, 130°01'17E).

Many of the smaller limestone islands are undercut at the highwater line into toadstool platforms, or are sculpted into steep conical stacks (Fig. 26). Oftentimes the sides of the taller islands have dizzying vertical faces that plunge for hundreds of feet (Figs. 27, 28). On Wagmab, the stepped ledges have a stunted woody vegetation, frequently wind-sheared, comprised of *Stenocarpus moorei*, *Exocarpos latifolius*, *Polyscias* sp. nov., *Wikstroemia androsaemifolia*,

²The FIMS code is partly based on the dominance of *Gymnostoma papuanum* (= *Casuarina papuana*) which is replaced by *Gymnostoma rumphianum* (= *Casuarina rumphiana*) in the Raja Ampat. The second species is a relatively minor element in the limestone flora but a conspicuous emergent on ultrabasics. In conformity with FIMS convention, the Raja Ampat code would be rendered as 'HsCr', or 'HsGr' in any extension of the typing system to Western New Guinea.

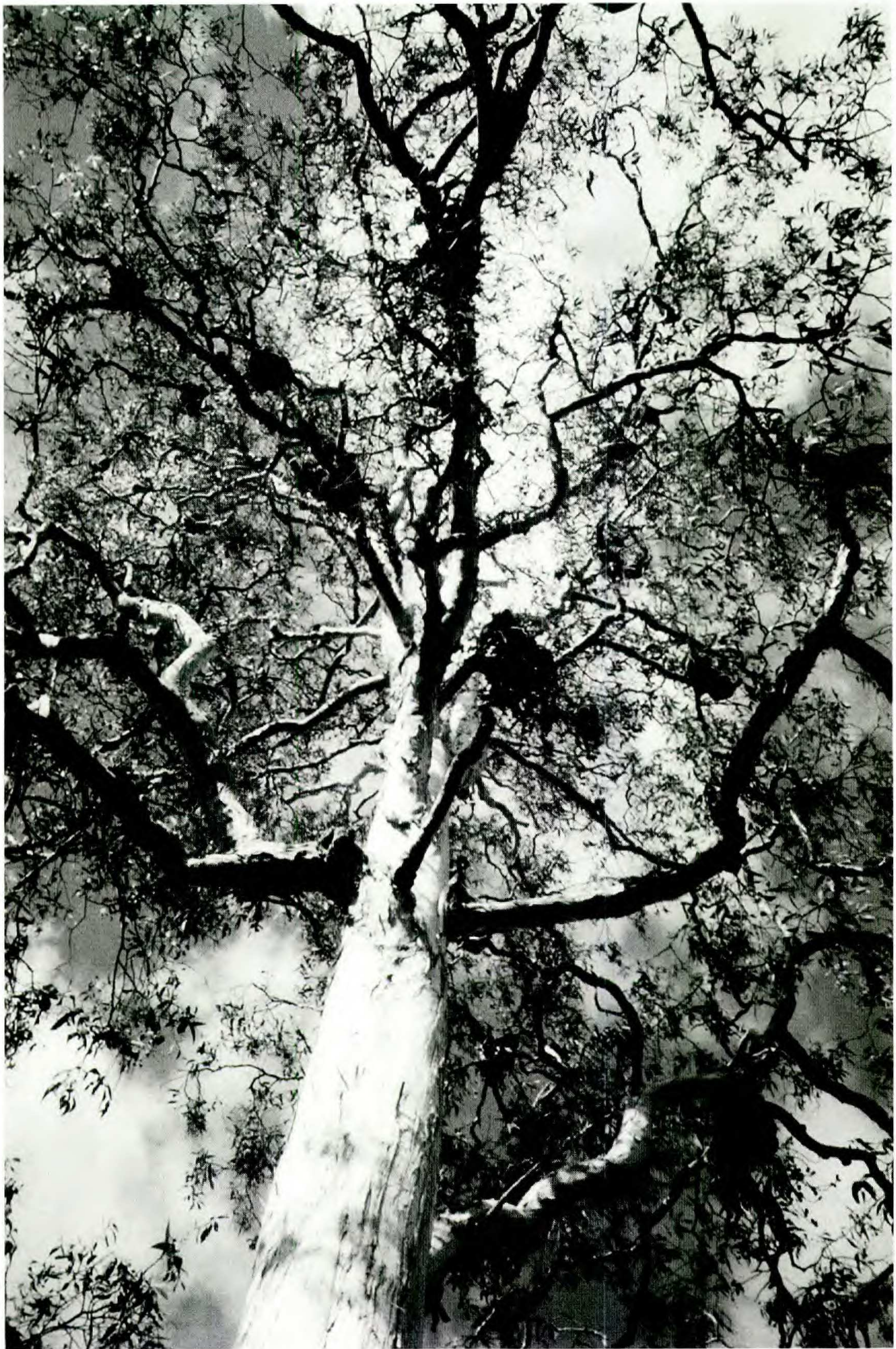


FIG. 22. Misool. *Melaleuca leucadendron* s.l., the dominant stand-forming species in the Raja Ampat savannas. The whitish-papery outer bark and drooping leaves are characteristic. Photo November 10, 2002.



FIG. 23. Misool. Kasim river savanna. *Timonius timon* forms a second, darker-leaved layer beneath taller *Melaleuca*. Photo November 10, 2002.



FIG. 24. As for Fig. 23. The grassy groundcover of *Ischaemum barbatum* and *Imperata conferta* is typical. Photo November 10, 2002.

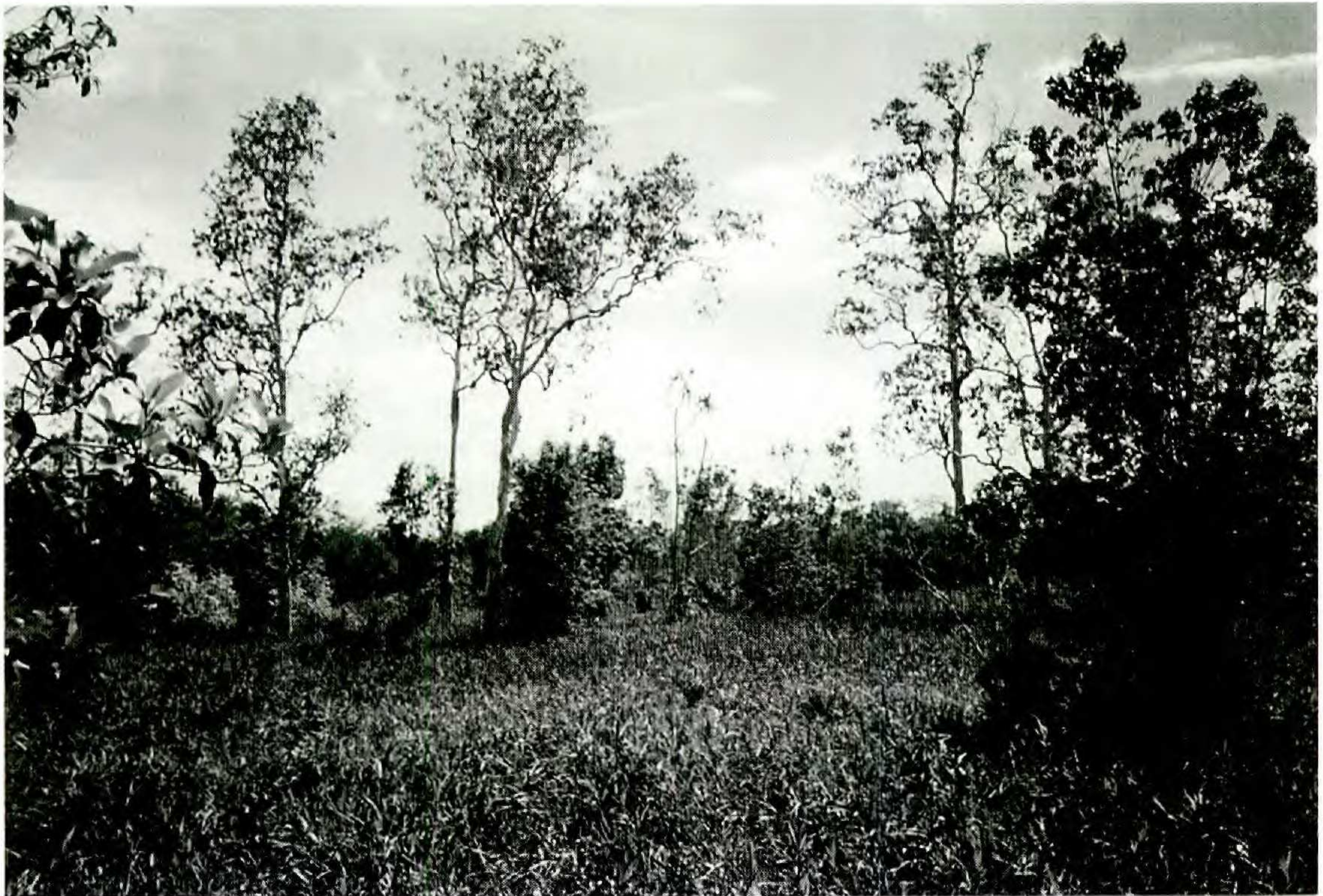


FIG. 25. Misool. The large savanna complex at Waitama. Photo November 11, 2002.



FIG. 26. Aljoei. Steep sided stacks and platforms, a typical geomorphic feature of the limestone terrain at Misool and Waigeo. Photo November 14, 2002.

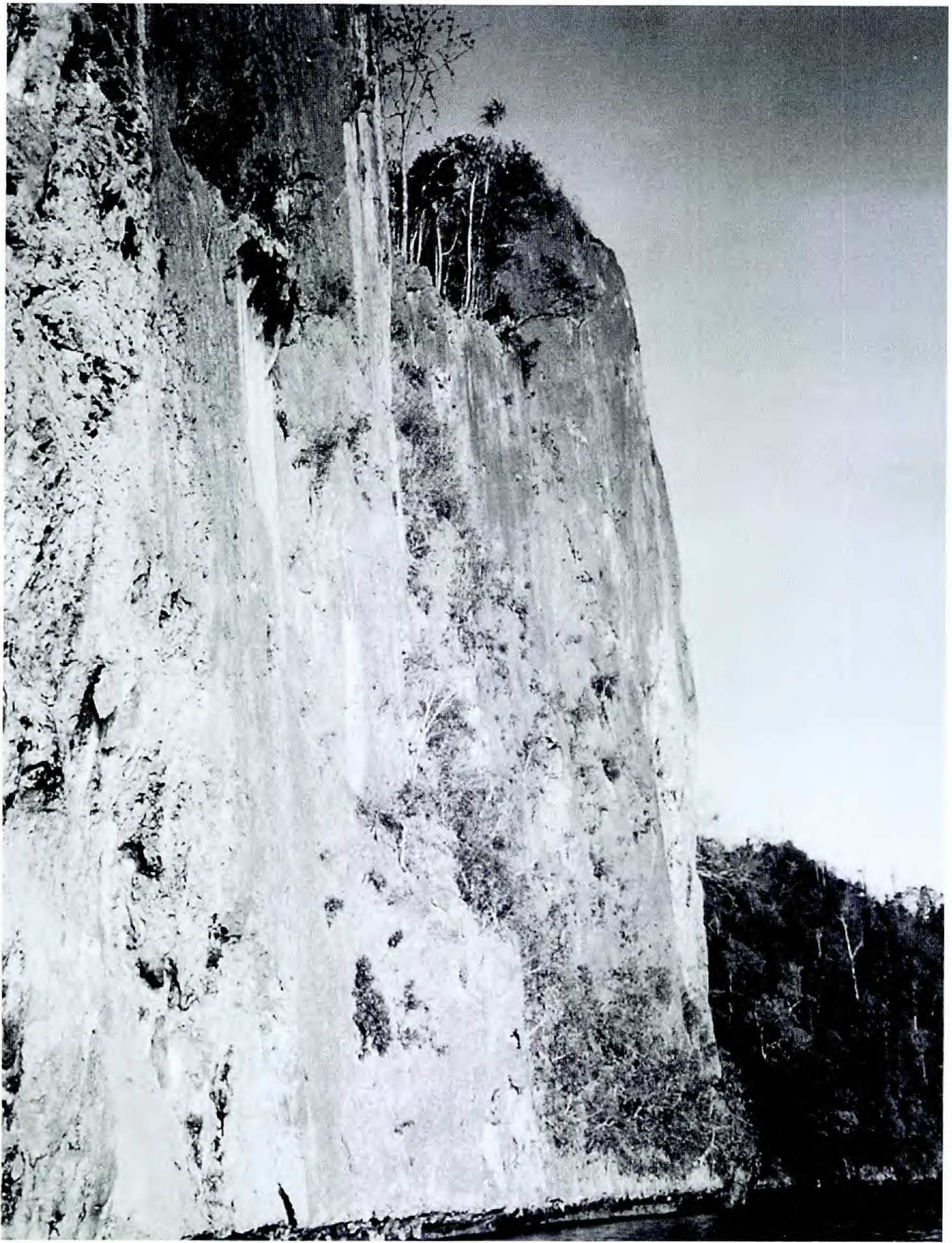


FIG. 27. Aljoei. Limestone cliffs. Labyrinthine submarine caves are present along many of the underwater walls. Photo November 14, 2002.

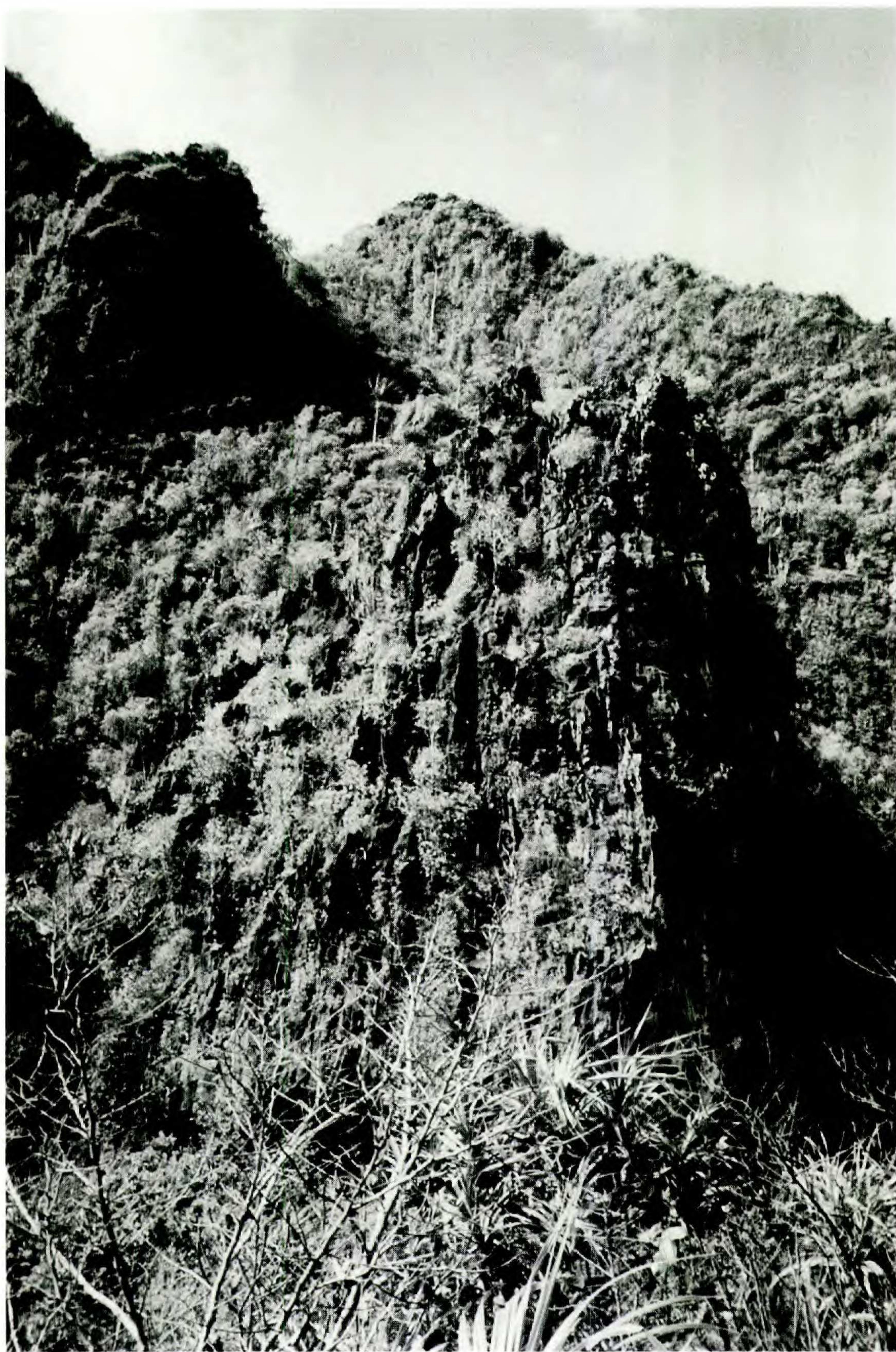


FIG. 28. Limestone precipices on Wagnab. Photo November 4, 2002.

Calophyllum spp. (including the *novoguineense* complex; cf. Stevens 1995), and many vines of *Alyxia purpureoclada* (Fig. 29). The unusual *Podocarpus polystachyus* is a dwarfed *krummholz* on solid rock, sprawling across ledges and barely ascending to 1 m height. But at Wayag, crestline populations of the same species grow as erect trees to 7 m height (Fig. 30; 0°10'25N, 130°01'22E and 0°10'42N, 130°01'16E).

On nearly all the limestone islands, *Gulubia costata* is a conspicuous emergent, often forming dense stands along the higher slopes and crestlines. *Barringtonia*, *Dracaena*, *Ficus*, *Garcinia*, *Gynotroches*, *Myrsine* (*Rapanea*), *Pouteria* (*Planchonella*), *Schefflera*, *Serianthes*, and *Sterculia* are also common subarborescent genera, but a disproportionate number of morphospecies were documented only by sterile or scrappy vouchers and cannot be identified with certainty. Of all the Raja Ampat habitats, the limestone vegetation was the most severely affected by the El Niño drought, and effective documentation of such communities was very difficult under the prevailing conditions. The canopies on most islands were brown and withered, though probably not dead. Limestone karst is undoubtedly a poor reservoir for soil moisture. Especially on small islands, stands with green foliage were often restricted to the colluvial accumulations in valleys and small draws (Figs. 11, 12).

Archidendron paluense, *Lunasia amara* var. *amara*, and the vinelike *Bauhinia binata* (*Lysiphyllum binatum*) were common taxa in karst understories of the western Raja Ampat, especially on platforms and stacks around Misool proper. At Mesemta Bajampop, substantial populations of *Rauvolfia moluccana* and *Monophyllaea* were also noted. The *Archidendron*, *Bauhinia*, *Monophyllaea*, and *Rauvolfia* were newly recorded for the district (cf. Burtt 1978; Verdcourt 1979; Nielsen et al. 1984; Hendrian & Middleton 1999). New registers for such common or conspicuous plants are indications of the undercollected status of the limestone, and show how poorly documented this flora still remains even after more than a century of Papuan exploration.

Lowland ultrabasic scrub and forest.—(W, HsCp) Renowned in scientific literature, the Raja Ampat serpentine flora is also one of the region's most picturesque environments. At Kawe (Figs. 31, 32) and Waigeo's north shore (Fig. 33) the ultrabasic scrub affords breathtaking panoramas of turquoise reefs and red laterite across extensive stretches of coastline.

The TNC survey explored the ultrabasic zone in a series of ascents along steep-sided buttress ridges. Most of the vegetation consisted of xeromorphic scrub or woodland with similar characteristics to communities described in an earlier account of the eastern Waigeo peninsula (Royen 1960).

During the first landfalls on Kawe (ending at 0°03'07S, 130°08'05E), the forest team found a distinctive woodland of *Ploiarium sessile*, *Exocarpos latifolius*, *Gymnostoma rumphianum*, *Decaspermum bracteatum*, *Ixonanthes reticulata*, and *Myrsine rawacensis* (Fig. 34). The spreading sympodial crowns of *Ploiarium*

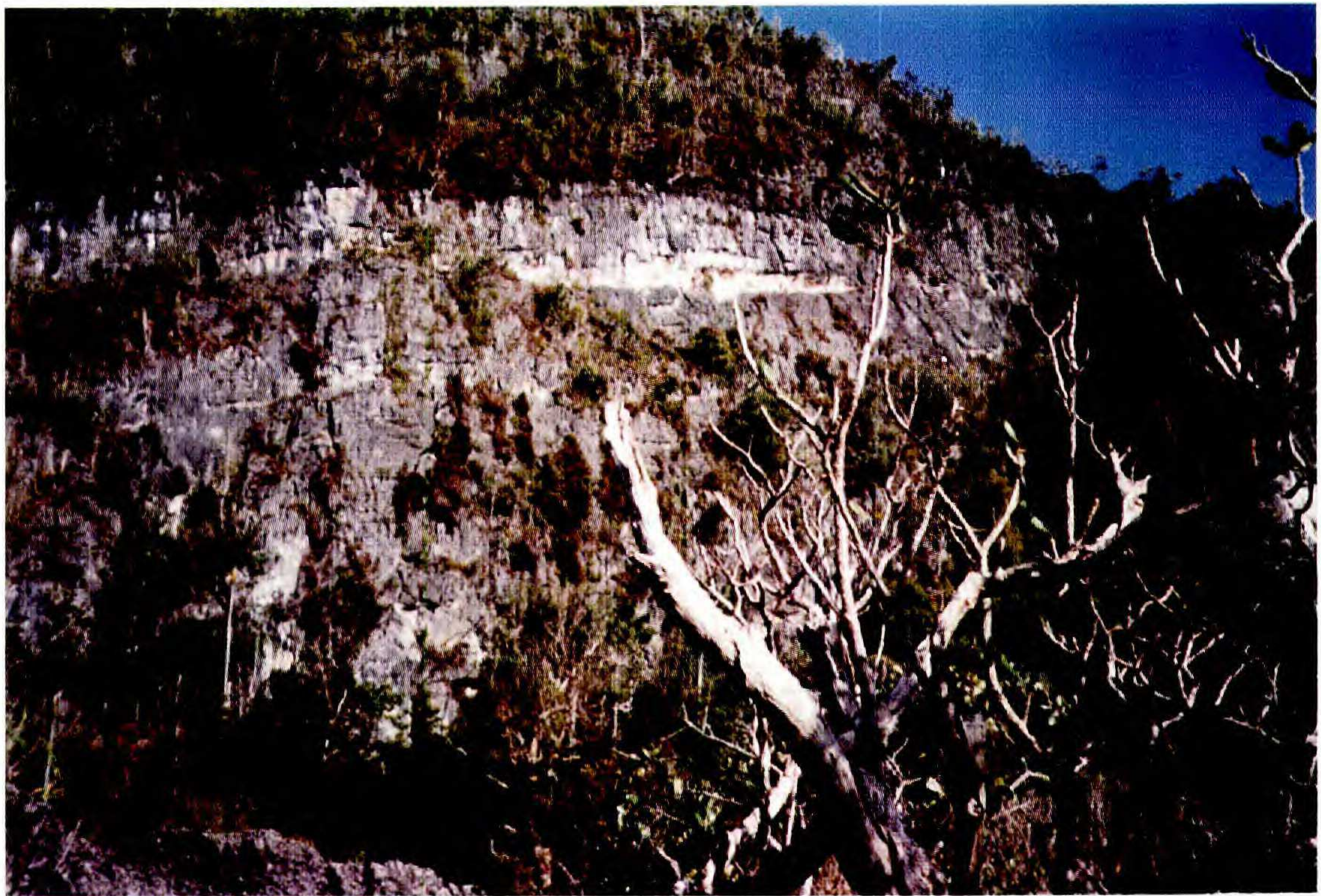


FIG. 29. Wagnab. Vegetation on limestone ledges. Photo November 4, 2002.

sessile were a particularly striking characteristic of this community (Fig. 35). In the wide spaces between the larger trees were many shrubs of *Myrtella beccarii*, *Styphelia abnormis* and (in lesser numbers) *Dodonaea viscosa*. Vines of *Alyxia laurina* were common climbers and scramblers. Patches of *Dicranopteris linearis* blanketed the ground nearly everywhere, with *Dianella ensifolia*, *Nepenthes danseri*, *Palhinhaea cernua*, *Machaerina disticha*, and *M. glomerata* scattered mainly over the bare spaces. *Artocarpus*, *Livistona*, and *Vitex* were common on lower slopes and valley floors (Fig. 36; 0°03'05S, 130°08'24E).

On the Go Isthmus of Waigeo (Fofak Bay at 0°02'22S, 130°43'43E), the ultrabasics were similar though somewhat richer, and also included *Arytera littoralis*, a small-leaved *Gmelina*, *Melastoma malabathricum* ssp. *malabathricum*, *Psychotria tripedunculata* (Fig. 37), and *Rhodamnia novoguineensis* among the common woody plants. Parts of the scrubland above the bay had been burned, exposing large patches of the distinctive red laterite (Fig. 38). Within such areas, the early fire succession consisted of a sparse association of *Commersonia bartramia*, *Myrtella beccarii*, *Scaevola oppositifolia*, and *Styphelia abnormis*. Although the ridgetop habitats are generally of open aspect, the vegetation in the draws is a closed codominant forest of *Dillenia alata* and *Calophyllum* spp. At scattered places in the ultrabasic zone (on both crestlines and depressional areas), the scrub is replaced by a taller *Gymnostoma rumphianum*-Sapindaceous



FIG. 30. Wayag. *Podocarpus polystachyus* (5–7 m tall), a common limestone species. Photo November 16, 2002.

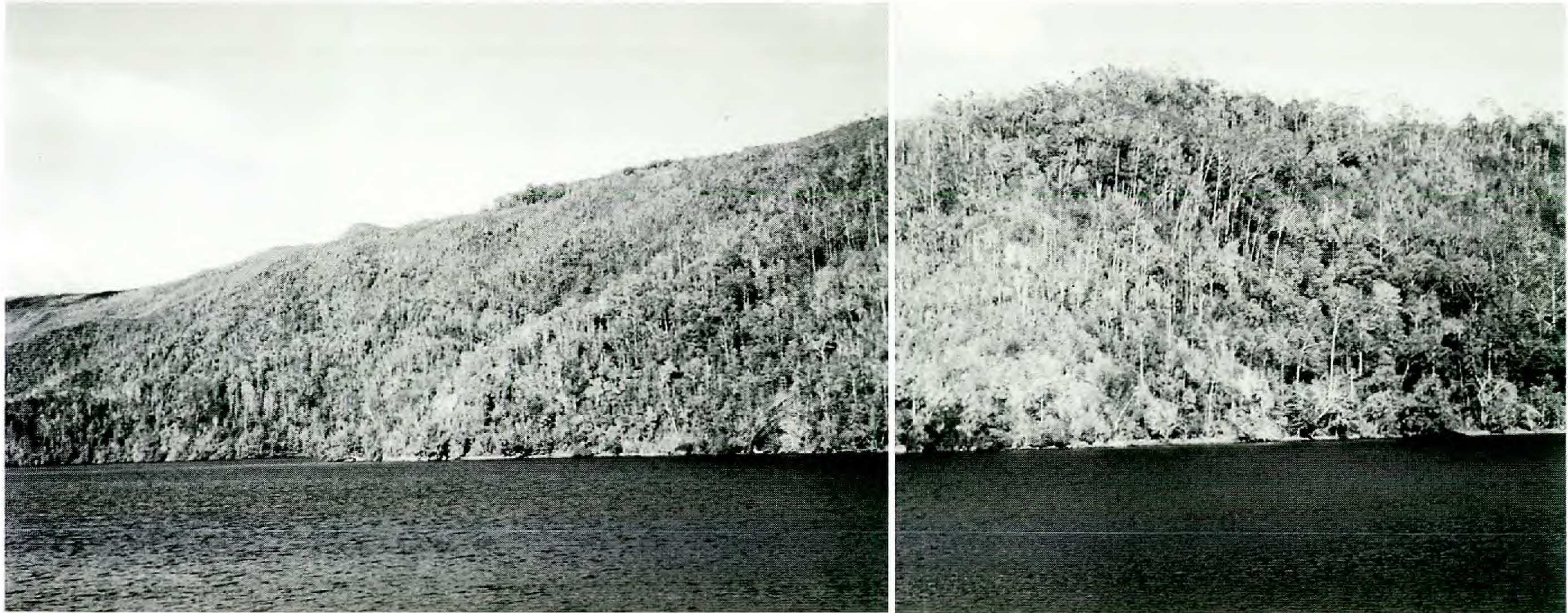


FIG. 31. East-central coastline of Kawe island, an ultrabasic outcrop 15 km west of Waigeo. In contrast to the uneven and deeply dissected limestone, ultrabasics are characteristically composed of massive ridges with uniform slopes (Löffler 1977). Photo November 18, 2002.



FIG. 32. Kawe. Three-shot montage (moving N to ESE: top frame to bottom frame) of ultrabasic woodland near the summit. The equator passes slightly to the right of the small island in the near background (center photo). Western Waigeo is on the horizon of the last frame (to ESE). Photo November 17, 2002.



FIG. 33. Waigeo ultrabasic scrub at the entrance of Fofak Bay. Center of view to the southeast, showing the irregular outline of limestone karst against the skyline (compare Fig. 31 Kawe island). Foreground: the sympodial architecture of *Ploiarium sessile* is the most distinctive feature of the open community. *Dicranopteris linearis* forms the groundlayer. Photo November 19, 2002.



FIG. 34. *Myrsine rawacensis* on Kawe ultrabasics. Photo November 17, 2002.



FIG. 35. *Ploiarium sessile*, the dominant woody plant in the ultrabasic scrub. Obtuse leaves and sessile flowers immediately distinguish this species from congeners (Kobuski 1950). Originally recorded from Halmahera (ibid.), *P. sessile* is still known from only a few collections. Photo November 17, 2002.

canopy with a *Myrtella beccarii* understory (e.g. at Kabare, 0°04'18S, 130°56'36E; Figs. 39, 40). Unlike the open growth, this taller community (at Kabare) is densely stocked with 7–10 m pole-trees including the serpentine indicator *Ploiarium sessile*. *Gymnostoma rumphianum* is a 25 m emergent in such situations. The ultrabasic vegetation is thus represented by several communities, collectively forming an intergrading series of facies ranging from bare 'blow-outs' (Fig. 41) through woodland of varying densities, then finally to a closed multistoried forest.

DISCUSSION

Raja Ampat plant communities are primarily lowland environments. There are no areas of significant size higher than the 900–1000 m level where montane conditions generally begin (cf. Paijmans 1975, 1976; Johns 1977; Grubb & Stevens 1985; Hammermaster & Saunders 1995a). Although Royen (1960) describes a mossy montane forest on Mt Buffelhoorn, such habitats could not be visited within the time allowed by the survey schedule. None of the daily excursions from the coast were able to penetrate beyond 500 m elevation.

Within the limitations imposed by rapid assessment, it is apparent that



FIG. 36. Serpentine bedrock in a large V-valley of south-central Kawe. In spite of the drought, a spring-fed creek flowed for several hundred meters over waterfalls in the middle valley, before disappearing into crevices along the streambed. A locally-luxuriant vegetation flourished along the banks, with dry woodland (Fig. 6) covering the higher slopes. No aquatic life was present other than small shrimp. Photo November 18, 2002.



FIG. 37. The aptly-named *Psychotria tripedunculata*, one of the most common shrubs on the ultrabasics. Photo November 19, 2002.

FIG. 38. Waigeo fire successional community. Burning removes the normal groundlayer of *Dicranopteris linearis* and *Machaerina glomerata*, leaving mainly scattered shrubs of *Commersonia bartramia*. Photo November 19, 2002.

FIG. 39. A closed stand of pole-stemmed trees near the fire succession shown in Fig. 38. The ultrabasic forest facies is connected to the open vegetation by a continuum of transitional communities. Photo November 19, 2002.



FIG. 40. Ultrabasic forest at Kabare. Showing the closed structure of the presumably older growth, often *Gymnostoma-Myrtella* codominant. Photo November 20, 2002.



FIG. 41. Waigeo blowout. Large patches of sheet-eroded earth are scattered through the scrubland, exposing the distinctive orange-red laterite of the ultrabasic zone. These erosional features are probably a recent result of forest removal. Although the open communities convey an impression of stability and continuity, the development of such areas is actually part of a historical pattern of ecological degradation. Photo November 19, 2002.

the Raja Ampat flora is depauperate and disharmonic relative to adjacent mainland environments and that these distinctions become more pronounced in the outer island groups (e.g. Misool and Waigeo). Many of the most characteristic Papuan families, including Annonaceae, Elaeocarpaceae, Gesneriaceae, Lauraceae, Melastomataceae, Meliaceae, Piperaceae, and Urticaceae, were poorly represented in the lowland habitats where they are ordinarily prominent. Epiphytes and climbers were also generally scarce, as were several herbaceous families usually found in New Guinea forest understories (e.g. Marantaceae, Orchidaceae, Zingiberaceae).

This westward trend of diminishing diversity across the archipelago is correlated to a general reduction in rainfall and to the limiting nature of the western substrates. Rainfall is directly correlated with floristic diversity, more than with any other abiotic factor (Gentry 1988). The perception of highest richness in the near-mainland environments of Salawati and Batanta, and the impression of lower species counts toward the outer groups, is consistent with annual rainfalls (cf. Mangel 1993): Salawati and Batanta (3000–3500 mm); Misool (2500–3000 mm); Waigeo and adjacent islands (1500–2000 mm). The floristic trends expected from moisture availability are enhanced by the substrate dis-



FIG. 42. Kamiali, Papua New Guinea. Successional scrub community on a 15-year old landslide. Plants on the exposed ground include *Myrtella beccarii*, *Stenocarpus moorei*, *Dicranopteris linearis*, *Machaerina glomerata*, and *M. rubiginosa*. The dominance of Cyperaceae (particularly *Machaerina*) is a curious feature of the ground layer in situations where grasses would ordinarily dominate on conventional substrates. This same pattern occurs on Waigeo serpentine. Photo Feb. 5, 2003.

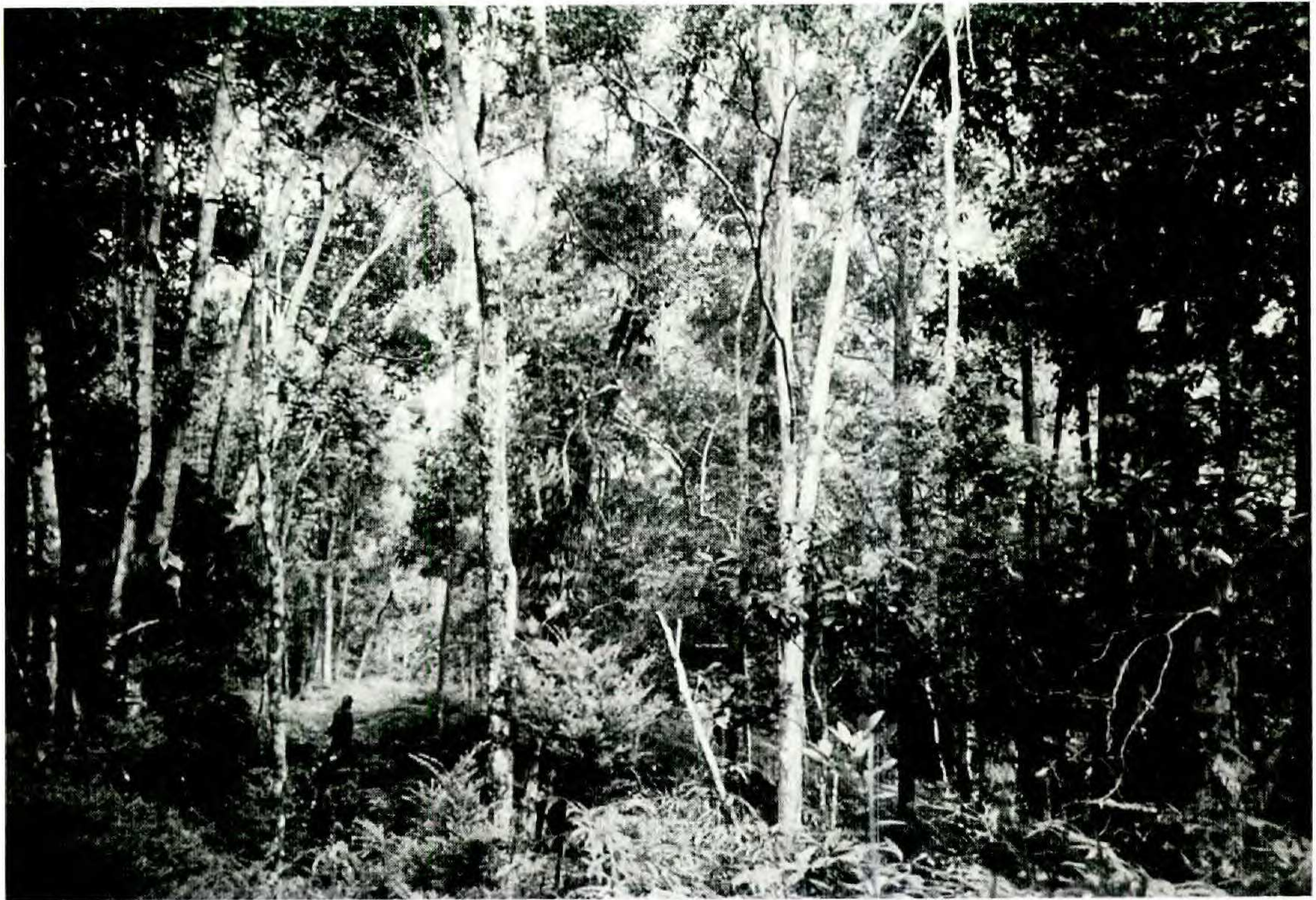


FIG. 43. Kamiali, Papua New Guinea. Serpentine woodland dominated by *Gymnostoma papuana*, *Weinmannia fraxinea*, and *Tristanopsis macrosperma* in the canopy, and by *Dicranopteris linearis* and *Myrtella beccarii* in the understory. Kamiali has about twice the rainfall of Waigeo, resulting in a denser and more diverse vegetation. Many species are common to both districts. Photo October 6, 2002.

tinctions. Whereas most edaphic environments in the eastern islands are of mineralized soil, the outer islands are predominantly limestone or ultrabasics, infertile substrates that are known to be limiting for plant growth (Royen 1963; Kruckeberg 1985; Brooks 1987). The synergistic combination of factors results in diminished richness but increased endemism.

In terms of exploration priorities, the highest potential for taxonomic discovery is probably with the Misool karst. Waigeo ultrabasics are comparatively easy to access and the communities are usually of low stature and density, characteristics which favor collection saturation. Most, if not all, of the ultrabasic endemics have probably been discovered. In contrast, the Misool limestone is wetter (notwithstanding conditions during the survey), very difficult to traverse, and suitable collections are much harder to find. A significant number of unknown taxa is likely to be present on the karst. The new distributional records from the survey are suggestive of future opportunities.

Conservation Assets.—When judged on the basis of uniqueness, the ultrabasic and limestone vegetation are the highest-value communities in the Raja Ampat. As presently known, the ultrabasics have more species endemic to its habitats than any of the other communities. Plants restricted to Waigeo ser-



FIG. 44. Peninsula at mouth of Fofak Bay, Waigeo. Inland view to the north (opposite the perspective in Fig. 33). Mapped as a *Gymnostoma* (*Casuarina*) forest in 1955, this area is now an eroded and depauperate scrubland. A few relictual emergents of *Gymnostoma rumphiana* are visible in the far distance, apparently all which remains of the former forest. Photo November 19, 2002.

pentine include *Alstonia beatricis*, *Alyxia laurina*, *Archidendron royenii*, *Guioa waigeoensis*, and *Maesa rheophytica*. *Psychotria tripedunculata* is also known primarily from the ultrabasics, with only one record originating elsewhere.

Waigeo's floristic patterns can be understood by comparison with similar areas from other districts in New Guinea. In the Bowutu Mts of Morobe Province, an elevational sequence of ultrabasic landscapes forms one of the largest features of this type in Papuasia (i.e. the Papuan Ultrabasic Belt, cf. Thompson & Fisher 1965; Bain 1973; Löffler 1977). Especially within the Kamiali Wildlife Management Area (KWMA), the serpentine flora extends across a series of coastal communities beginning at sealevel, in a manner analogous to Waigeo.

KWMA habitats are subject to frequent landslides because of a local combination of humid climate and steep coastal ridges. In the recovery following landslides, the community that develops is a scrub composed primarily of *Myrtella beccarii*, *Dicranopteris linearis*, *Machaerina glomerata*, and *M. rubiginosa*; with (at lesser frequencies) *Stenocarpus moorei* and *Tristaniopsis macrosperma* (Fig. 42). In appearance and composition, the pioneer community is very similar to the Waigeo scrubland and also occurs alongside a series of taller forests including many of the same elements (Fig. 43). The KWMA

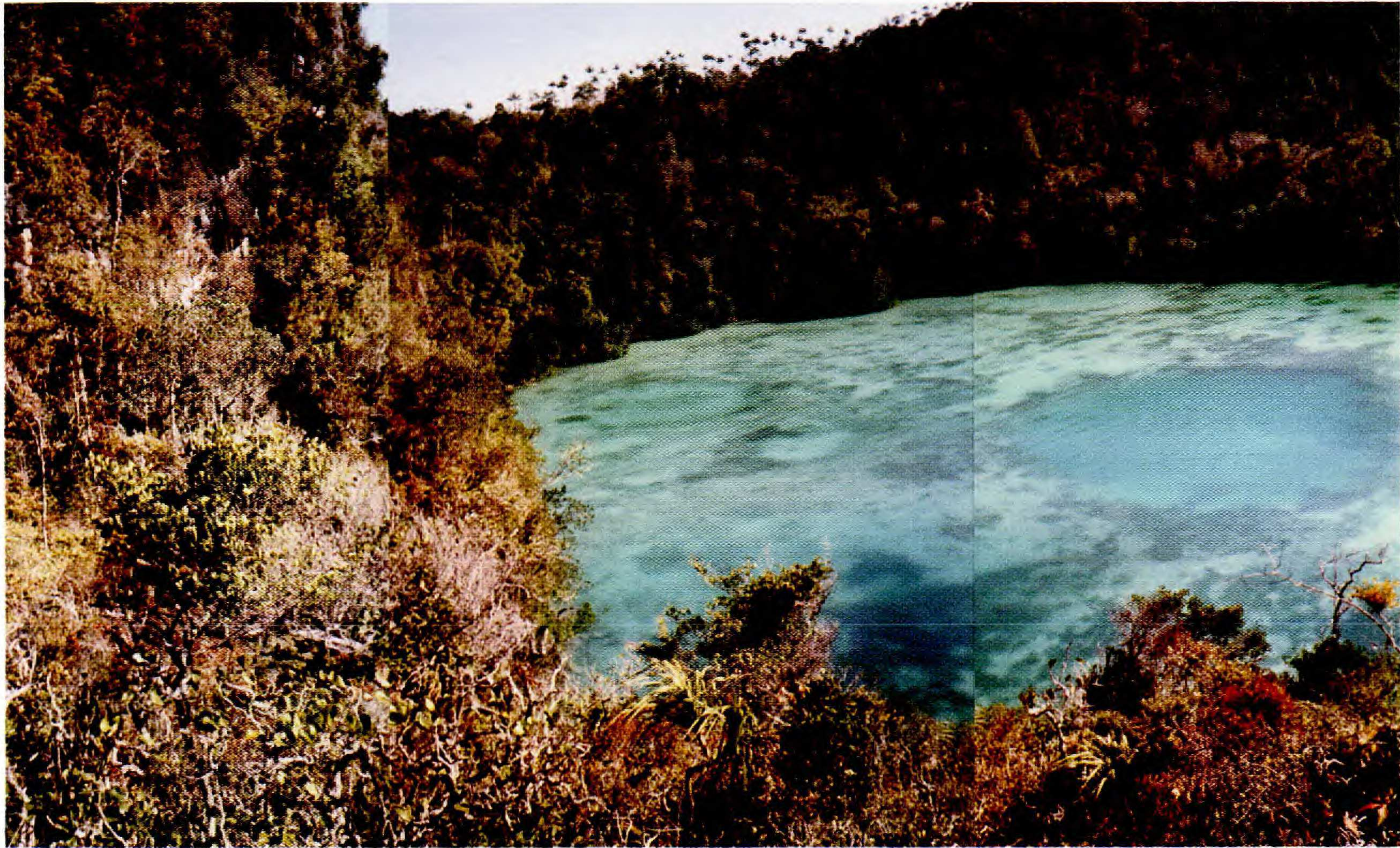


FIG. 45. Mesemta Bajampop. Scenic limestone forests adjoining a sheltered reef teeming with marine life. Some of the highest coral counts during the survey were recorded from this reef, e.g. from the blue hole in the right frame (Turak, pers. comm.). Photo November 5, 2002.

community variation clearly represents a successional sequence, which can be tracked because of the known history of specific sites.

Royen (1960: 41) described the Waigeo scrub as an edaphic climax, but its spatial proximity and structural resemblance to other communities suggest otherwise. By analogy to similar environments, most of the Waigeo ultrabasics are probably an early stage in a successional sequence caused by fire. The principal characteristics of the open scrub are hardly different from landslide seres of the KWMA, except that the Waigeo communities are much larger, extending continuously over hundreds of hectares. The distinction in spatial scale can be attributed to the presumed fire etiology, which would tend to act over much larger areas than landslides. The etiologies can themselves be explained by the climatic contrasts between the sites. Fires are a common ecological factor in dry environments like Waigeo, while humid localities (KWMA rainfalls are 4000 mm per annum) are naturally susceptible to landslides during periods of heavy rain. Royen's own observations provide evidence of instability in the Raja Ampat ultrabasic vegetation (Royen 1960). The ridge in the foreground of Figs. 33 and 41 was a *Gymnostoma* (= *Casuarina*) forest in 1955 (ibid.: Fig. 5). As documented by the TNC survey, that forest now remains only as relictual trees surrounded by scrubland (Fig. 44). These open areas are clearly a new development and not a permanent edaphically-induced feature.

The frequent occurrence of fires is currently reflected in the patchy distributions of ultrabasic forest on Waigeo, an expected pattern if seral sequences are being continuously reset over large areas. Although the serpentine scrubland is one of Papuasias's most impressive environments, the rare and endemic taxa are concentrated in the taller vegetation, and this latter habitat probably represents a more valuable conservation asset. In an environment with fire-induced succession, the closed forest (Figs. 39, 40) should be the richest community, and thus the more promising target for future exploration.

Apart from the biotic measures, aesthetic considerations are a legitimate part of any environmental evaluation. Waigeo and Misool landscapes are very photogenic, and can serve as focal assets for an ecotourism niche market in combination with the marine attractions, as already demonstrated by the *Pindito* (www.pindito.com).

Ecosystem Threats.—During the last 50 years, the areas of post-fire succession in northern Waigeo have expanded substantially (compare Royen 1960: Figs. 3, 5). Several endemic plants are probably being threatened by the existence of this historical trend, particularly by the accompanying reductions of taller communities. Among ultrabasic species, *Archidendron royenii*, *Alstonia beatricis*, and *Maesa rheophytica* are still known only from their types, taken in primary forest or older-growth woodland (see Nielsen et al. 1984; Sidiyasa 1998; Sleumer 1987). From the circumstances of their collection, these plants are probably associated with the advanced stages of the ultrabasic succession,

and their apparent rarity is consistent with habitat reduction caused by increased fire frequency. In contrast, the ultrabasic endemics *Guioa waigeoensis* and *Alyxia laurina* are known by several collections from the open areas, and are probably seral taxa (cf. Welzen 1989; Middleton 2000).

Naturalized alien plants were not found on serpentine, or on most of the isolated karst islands at Aljoei and Mesemta Bajampop. Although limestone areas near human settlements often have a few adventives (viz. *Bidens pilosa*, *Boerhavia erecta*, *Euphorbia heterophylla*, *E. hirta*, *Passiflora foetida*, *Stachytarpheta jamaicensis*, *Tridax procumbens* etc.) truly invasive taxa were absent. The noxious *Lantana camara* and *Piper aduncum* were recorded only on Batanta and Salawati. The same factors which make the western environments limiting for plant growth apparently act to discourage the establishment of aliens.

A planted patch of *Hibiscus rosa-sinensis* was seen at uninhabited Wagemab, and even if such occurrences are not threatening, deliberate introductions into otherwise weed-free habitats need to be discouraged by proactive conservation policy. Predictive guidelines for assessing possible invasive success of alien plants have been developed for other island environments (cf. Pheloung et al. 1999; Daehler & Denslow 2002). Their application should be considered by Papuan managers administering conservation tracts, as most communities in the western Raja Ampat are of entirely indigenous or endemic composition. Nowadays, in a world where the spread of aggressive species contributes to homogenization of floras, areas such as the Misool karst are an increasingly rare ecological resource.

Each of the principal islands (Batanta, Misool, Salawati, Waigeo) have sizable set-aside areas designated as nature preserves (Supriatna 1999). However existing logging threats are substantial, and commercial operations were filmed during the recent TNC assessment even within the so-called reserves. Although the archipelago is known to have significant plant and faunal assets, many of these are under threat and will require management action to ensure their continuity (ibid.). Establishing new incentives for conservation will not be easy, since in most Raja Ampat forests the emergent canopy is composed of major exportable timbers (*Intsia bijuga*, *I. palembanica*, *Pometia pinnata*, *Flindersia amboinensis*, *Vatica rassak*; see Louman & Nicholls 1995) occurring at stocking densities which favor profitable extraction (Departemen Pertanian Direktorat 1977). Although the current concessional areas are habitats with good site capacities for tree growth, the ultrabasics and limestone karst have stunted vegetation of little value as logging targets, and are thus at lesser economic risk.

Despite indications that climatic warming will cause substantial reductions in Papua's rainforest biome, there have been no attempts to define local planning and management responses to this threat. Baselines are much needed for determining the onset and direction of climate-induced change in a variety

of communities. Because of their insular and pristine status, many Raja Ampat environments would make appropriate stations for monitoring the floristic effects of El Niño oscillations. The western islands are part of a forest continuum spatially connected to perhumid mainland habitats, extending across a geographic sequence of sparsely inhabited landscape, tectonic, and biotic environments. The district is very suitable as a venue for ecological research.

Nearly all conservation programs in New Guinea are committed exclusively to terrestrial or marine habitats, due to the disparate value of such environments when they occur together at most sites. However at Misool and Waigeo, highly endemic forest communities lie alongside some of the most diverse reef ecosystems in the world (Fig. 45). This unusual combination of worldclass assets will permit development of holistic strategies for managing the linked land-sea resources. The information needs for integrated planning will be complex, requiring data inputs on wildlife, floristic, recreational, cultural-political, landscape, and human subsistence values. But owing to the unique nature of the environmental assets in this district, future initiatives have the opportunity of being cost-effective, innovative, and compelling.

APPENDIX OF BINOMIALS CITED IN THE TEXT

- | | |
|--|---|
| <i>Aglaiia argentea</i> Bl. (Meliaceae) | <i>Conandrium polyanthum</i> (Laut. & K. Schum.) |
| <i>Alstonia beatricis</i> Sidiyasa (Apocynaceae) | Mez (Myrsinaceae) |
| <i>Alstonia scholaris</i> (L.) R. Br. (Apocynaceae) | <i>Decaspermum bracteatum</i> (Roxb.) A.J. Scott |
| <i>Alyxia laurina</i> Gaudich. (Apocynaceae) | (Myrtaceae) |
| <i>Alyxia purpureoclada</i> Kaneh. & Hatus. | <i>Derris indica</i> (Lam.) J.J. Bennett (Fabaceae) |
| (Apocynaceae) | <i>Desmodium umbellatum</i> (L.) DC. (Fabaceae) |
| <i>Archidendron paluense</i> (Kaneh.) Nielsen | <i>Dianella ensifolia</i> (L.) DC. (Liliaceae) |
| (Mimosaceae) | <i>Dicranopteris linearis</i> (Burm.f.) Underw. |
| <i>Archidendron royenii</i> Kosterm. (Mimosaceae) | (Gleicheniaceae) |
| <i>Arytera littoralis</i> Bl. (Sapindaceae) | <i>Dillenia alata</i> (R. Br. ex DC.) Martelli |
| <i>Baeckea frutescens</i> L. (Myrtaceae) | (Dilleniaceae) |
| <i>Bauhinia binata</i> Blanco (Caesalpiniaceae) | <i>Dodonaea viscosa</i> Jacq. (Sapindaceae) |
| <i>Bidens pilosa</i> L. (Asteraceae) | <i>Dolichandrone spathacea</i> (L.f.) K. Schum. |
| <i>Boerhavia erecta</i> L. (Nyctaginaceae) | (Bignoniaceae) |
| <i>Bruguiera gymnorhiza</i> (L.) Lamk | <i>Dracaena angustifolia</i> Roxb. (Dracaenaceae) |
| (Rhizophoraceae) | <i>Eucalyptus papuana</i> White (Myrtaceae) |
| <i>Calophyllum inophyllum</i> L. (Clusiaceae) | <i>Euphorbia heterophylla</i> L. (Euphorbiaceae) |
| <i>Casuarina equisetifolia</i> Forst. & Forst. f. | <i>Euphorbia hirta</i> L. (Euphorbiaceae) |
| (Casuarinaceae) | <i>Exocarpos latifolius</i> R. Br. (Santalaceae) |
| <i>Casuarina papuana</i> S. Moore (Casuarinaceae) | <i>Ficus microcarpa</i> L. (Moraceae) |
| <i>Casuarina rumphiana</i> Miq. (Casuarinaceae) | <i>Ficus prasinocarpa</i> Elm. (Moraceae) |
| <i>Ceriops tagal</i> (Perr.) C.B. Rob. (Rhizophoraceae) | <i>Flindersia amboinensis</i> Poir. (Rutaceae) |
| <i>Codiaeum variegatum</i> (L.) Bl. var. <i>moluccanum</i> | <i>Flindersia laevigata</i> White & Francis var. <i>heterophylla</i> (Merr. & Perry) Hartley (Rutaceae) |
| (Decne) Muell. Arg. (Euphorbiaceae) | <i>Gahnia aspera</i> (R. Br.) Spreng. (Cyperaceae) |
| <i>Colubrina asiatica</i> Brogn. (Rhamnaceae) | <i>Gastonia serratifolia</i> (Miq.) Philipson |
| <i>Commersonia bartramia</i> (L.) Merr. | (Araliaceae) |
| (Sterculiaceae) | |

- Guioa waigeoensis* Welzen (Sapindaceae)
Gulubia costata Becc. (Arecaceae)
Gymnostoma papuanum (S. Moore) L.A.S. Johnson (Casuarinaceae)
Gymnostoma rumphianum (Miq.) L.A.S. Johnson (Casuarinaceae)
Heritiera littoralis Ait. (Sterculiaceae)
Hibiscus rosa-sinensis L. (Malvaceae)
Hibiscus tiliaceus L. (Malvaceae)
Homalium foetidum (Roxb.) Benth. (Flacourtiaceae)
Imperata conferta (Presl) Ohwi (Poaceae)
Intsia bijuga (Colebr.) O. Kuntze (Caesalpiniaceae)
Intsia palembanica Miq. (Caesalpiniaceae)
Ischaemum barbatum Retz. (Poaceae)
Ischaemum muticum L. (Poaceae)
Ixonanthes reticulata Jack (Ixonanthaceae)
Jagera javanica (Bl.) Bl. ex Kalkm. ssp. *javanica* (Sapindaceae)
Koordersiodendron pinnatum (Bl.) Merr. (Anacardiaceae)
Lantana camara L. (Verbenaceae)
Leea indica (Burm. f.) Merr. (Leeaceae)
Lunasia amara Blanco var. *amara* (Rutaceae)
Lysiphyllum binatum (Blanco) de Wit (Caesalpiniaceae)
Machaerina disticha (Clarke) Koyama (Cyperaceae)
Machaerina glomerata (Gaud.) Koyama (Cyperaceae)
Machaerina rubiginosa (Spreng.) Koyama (Cyperaceae)
Maesa rheophytica Sleumer (Myrsinaceae)
Maniltoa plurijuga Merr. & Perry (Caesalpiniaceae)
Maniltoa schefferi K. Schum. & Hollrung (Caesalpiniaceae)
Melaleuca leucadendron L. sens. lat. (Myrtaceae)
Melastoma malabathricum L. ssp. *malabathricum* (Melastomataceae)
Metroxylon sagu Rottb. (Arecaceae)
Morinda citrifolia L. (Rubiaceae)
Myrsine rawacensis A. DC. (Myrsinaceae)
Myrtella beccarii (F.v.M.) Diels (Myrtaceae)
Nepenthes danserii Jebb & Cheek (Nepenthaceae)
Nypa fruticans Wurmb (Arecaceae)
Osmoxylon sessiliflorum (Laut.) Philipson (Araliaceae)
Palhinhaea cernua (L.) Vasc. & Franco (Lycopodiaceae)
Pandanus tectorius Parkinson sens. lat. (Pandanaceae)
Parsonsia alboflavescens (Dennst.) Mabb. (Apocynaceae)
Passiflora foetida L. (Passifloraceae)
Piper aduncum L. (Piperaceae)
Ploiarium sessile (Scheff.) Hall. f. (Theaceae)
Podocarpus polystachyus R. Br. ex Endl. (Podocarpaceae)
Polyscias cumingiana (Presl) F.-Vill. (Araliaceae)
Pometia pinnata J.R. & G. Forst. (Sapindaceae)
Pongamia pinnata (L.) Pierre (Fabaceae)
Premna serratifolia L. (Verbenaceae)
Psychotria tripedunculata Sohmer (Rubiaceae)
Rauvolfia moluccana Markgrf. (Apocynaceae)
Rhizophora mucronata Lamk (Rhizophoraceae)
Rhodamnia novoguineensis A.J. Scott (Myrtaceae)
Rhynchospora rubra (Lour.) Makino (Cyperaceae)
Saccharum spontaneum L. (Poaceae)
Scaevola oppositifolia R. Br. (Goodeniaceae)
Scaevola sericea Vahl (Goodeniaceae)
Sophora tomentosa L. ssp. *tomentosa* (Fabaceae)
Spinifex littoreus (Burm. f.) Merr. (Poaceae)
Stachytarpheta jamaicensis (L.) M. Vahl (Verbenaceae)
Stenocarpus moorei F.v.M. (Proteaceae)
Styphelia abnormis (Sond.) J.J. Sm. (Epacridaceae)
Tacca leontopetaloides (L.) O.K. (Taccaceae)
Teijsmanniodendron bogoriense Koorders (Verbenaceae)
Terminalia catappa L. (Combretaceae)
Terminalia copelandii Elm. (Combretaceae)
Thespesia populnea (L.) Sol. ex Corr. (Malvaceae)
Timonius timon (Spreng.) Merr. (Rubiaceae)
Tournefortia argentea L.f. (Boraginaceae)
Trema cannabina Lour. (Ulmaceae)
Tridax procumbens L. (Asteraceae)
Tristaniopsis macrosperma (F. v. M.) Wilson & Waterh. (Myrtaceae)
Trophis philippinensis (Bur.) Corner (Moraceae)
Vatica rassak (Korth.) Bl. (Dipterocarpaceae)
Vigna marina (Burr.) Merr. (Fabaceae)
Vitex cofassus Reinw. ex Bl. (Verbenaceae)

Weinmannia fraxinea (D. Don) Miq.
(Cunoniaceae)

Wikstroemia androsaemifolia Decne
(Thymelaeaceae)

Ximenia americana L. var. *americana*
(Olacaceae)

Xylocarpus granatum Koenig (Meliaceae)

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The other expedition participants included Pawel Achtel (Jungle Run Productions, photographer), Gerald Allen (Western Australian Museum), Ryan Donnelly (environmental journalist), Fredy Frommenwiler (*Pindito* captain), Morgan Gabereau (Jungle Run Productions, producer and co-director), Creusa Thetha Hitipeuw (World Wildlife Fund Sahul), Djuna Ivereigh (Project Bird Watch), Agus Sumule (Universitas Negeri Papua), Yulianus Thebu (World Wildlife Fund Sahul), Emre Turak (Australian Institute for Marine Science), and Joe Yaggi (Jungle Run Productions, team leader).

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